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The Compared Number Density of High-Redshift Galaxies and Lyman α Clouds

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Abstract. We use our catalog of photometric redshifts in the Hubble Deep Field (HDF) to estimate the Luminosity Function (LF) of galaxies up to $z = 2$. Using the obtained LF and a relationship between luminosity and halo size, we calculate the expected density of galactic halo crossings for any arbitrary line of sight. This density is then compared with the known one of Lyman α lines, showing that the observed density of galaxies is enough to account for the observed absorption lines.

1 Galaxies, Luminosity Functions and QSO Absorbers

We have obtained a photometric redshift catalog [6] of objects in the HDF [8]. The catalog is complete to $AB(8140) = 28.0$, and it has been measured to be accurate to $\Delta z_{rms} = 0.15$ when compared to available spectroscopic values. As the HDF observations cover a wide wavelength range (3000–8000 Å), we can obtain the B-band rest-frame flux of every object with $z < 1.0$ and the U-band rest-frame flux of those with $z < 2.0$ without the need of applying any K-correction. This advantage, together with the unprecedented depth of the HDF images, allows us to estimate the B- and U-band LF down to very faint absolute magnitudes, and to break it in several redshift bins. Complete details of this procedure will be presented elsewhere, but we mention here that the obtained LFs show a steep increase in number in the faint end (at $M > -15$) and that there is no evidence for strong evolution up to $z = 1$, although number evolution might be necessary to fit the measured LF at higher z.

Recently Chen *et al.* [3] have shown the existence of a relationship between the luminosity of a galaxy and the size of the gaseous halo around it: $\rho \propto (L_B/L_B^*)^{0.31}$, where ρ is the minimum impact parameter at which a galaxy with luminosity L_B will produce an absorption line with EW$>$ 0.3 Å (using $H_0 = 100$ km s^{-1} Mpc^{-1} and $q_0 = 0.5$, [3] obtain $\rho = 120$ kpc for a L^* galaxy). This relationship, used in conjunction with the obtained LFs, allows us to calculate dN_{HC}/dz, the average expected density of "halo crossings" per unit redshift for a line of sight to a background QSO that would produce such lines. These numbers are plotted in Figure 1 (left), with different marks corresponding to the values obtained from the B- and U-band LFs at different redshifts. We have integrated the functions only down to $L = 0.01L^*$, although in none of the actual cases the function diverges when L tends to zero.

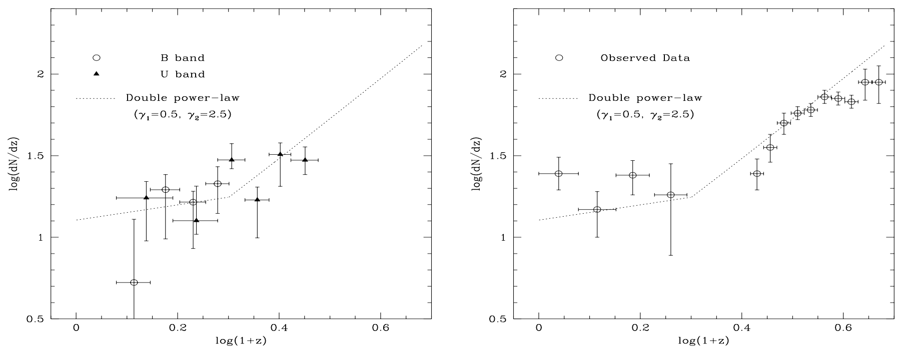

Figure 1: Redshift density of "halo-crossings" (left) and Lyman α absorbers (right). The dotted line is a typical double power-law fit used only as a guide.

2 Comparison with QSO Absorption Lines

The results described in [3] refer to galaxies over the redshift range 0.1–1.2. We are extending those results towards slightly higher values of z, but as high-z galaxies are expected to have even higher gas contents than their low-z counterparts, this represents a conservative estimate.

A direct comparison can be established with the known redshift evolution of Lyman α absorbers, $dN_{Ly\alpha}/dz$ ([1], [2]; see Figure 1 right). The plots show clearly that galaxies alone are able to account for *all* the absorption lines produced in QSO spectra up to redshifts $z \approx 2$. There is also a hint of a break in the function dN_{HC}/dz that can be compared to the one in $dN_{Ly\alpha}/dz$, although this result must be tested with LFs that extend to higher redshift.

These results, when taken together with recent measurements of the metal abundances of Lyman α clouds [4], their clustering properties [5] and the optical identification of the galaxies responsible for Lyman α absorption on QSOs [7], lead us to maintain that there seems to be little or no place for the hypothesis of a second intergalactic population of Lyman α clouds.

References

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